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## STUDY ON EFFECTIVE NOISE BARRIER AT SENIOR HIGH SCHOOL (SMAN 02) CIBINONG

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### ABSTRACT

**Aim:** The aim of this study is to design noise barrier shapes and to investigate its effectiveness in reducing traffic noise at one public school in Indonesia. **Methodology and Results:** Two types of barriers were designed on a laboratory scale using plywood materials and the noise level was measured using Noise Analyzer Briel and Kjaer Type 2250. Noise reduction was analyzed by using the Insertion Loss method based on the difference of the noise level before and after implementing the barrier. The results show that the barrier Type II with a length of 200 cm, a receiver height of 30 cm, and a curved shape of 45° angle (Type L) is more effective in reducing the noise than the other variation of barrier shape and length. Barrier Type L (Type II) can reduce the noise at high frequency between 1–8 kHz with an Insertion Loss value of 6.9–27.9 dB. **Conclusion, significance and impact study:** The noise barrier Type II, with specifications of 20 m length, 3 m height, and barrier material of reinforced concrete, is recommended to be used at the high school to reduce the road traffic noise.

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- Insertion loss
- Noise barrier
- SMAN 2 Cibinong
- Traffic noise

## 1. INTRODUCTION

The control of noise in an environment depends on two factors, the conditions of the atmosphere and other noise barriers such as walls or vegetation (Doelle, 1986). However, the efforts made, through the use of barrier, to ensure noise is reduced are affected by the materials used and the distance to the source (propagation variables). In the same vein, modification of the shape, length, and height of the receiver also affects the pattern of noise absorption on the barrier.

Increasing the number of transportation modes impacts air pollution and traffic noise and, consequently, leads to public discomfort. This is, nevertheless, affecting the students of SMAN 2 Cibinong located on the edge of the Karadenan Highway, Cibinong, West Java. The noise around this area was found to be high at  $\pm 60$  dB and exceeding the stated standard quality. However, the school building, like many other school structures, is generally expected to have a conducive atmosphere with a low level of noise to conduct academic activities. Therefore, one of the feasible ways to control traffic noise is by establishing a noise reduction structure through the use of a wall/building as the damper.

This study employed the Insertion Loss method to design an effective barrier and compare sound waves absorption with and without the barrier. This method is widely used in Indonesia and has been found to be very effective in calculating noise reduction and designing barriers. According to the guidelines of Planning Noise Reducer Building Techniques, there are three barrier shapes, and they include the standard forms (I shape), curved, and stylized. Therefore, this study was used to design an effective form and length of barrier to reduce the noise level.

## 2. RESEARCH METHODOLOGY

This research was conducted using the insertion loss method to compute the shadow zone required to yield the effective length of noise control barrier for SMAN 2 Cibinong. The Sound Pressure Level (SPL) was calculated based on the American National Standard Methods for Determination of Insertion Loss Outdoor Noise Barriers (ANSI) S 12.8 - 1998. The formula used to identify the value of Insertion Loss (IL) is as follows:

$$\text{Insertion Loss (dB)} = \text{Sound Pressure Level (SPL) with a barrier} - \text{SPL without a barrier} \quad (1)$$

Field observations were conducted on Karedenan Highway, 20 meters in front of research location and noise was measured by the Center of Research and Development on Environmental Quality and Laboratory, Ministry of Environment (Pusat Penelitian dan Pengembangan Kualitas dan Laboratorium Lingkungan/P3KLL). The barrier length was varied at 100, 180 and 200 cm and the receiver height at 30, 60, and 90 cm, while the distance between the source and the receiver was 160 cm. Furthermore, the required data was obtained by measuring sound pressure based on the frequency in 1/3 octave bands, i.e., 125 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz according to the basic concept of environmental noise control (Dodi, 2015) with a scale of 1 : 10. Two types of noise barrier, I and II (or type L) were designed in this study.

## 2.1 Measurement of Sound Pressure Level (SPL)

Sound pressure level (SPL) was measured by setting the speakers at the middle point of the receiver (microphone 1 emphasis) in accordance with Figure 1. Calculations of SPL value with and without a barrier (background) was conducted three times and the sound pressure average ( $L_p$ ) computed according to the ANSI S 12.8 - 1998 formula as follows:

$$L_p = 10 \log \left[ \sum_n^1 10^{0.1 L_{pi}} \right] \quad (2)$$

Note:  $L_{pi}$  =  $L_p$  value measured at each point (dB)

## 2.2 Measurement of Noise Level Background

The background noise was measured using two different treatments, without and with the sound source at a frequency of 12.5 Hz – 20 kHz in an anechoic room as shown in Figure 1.

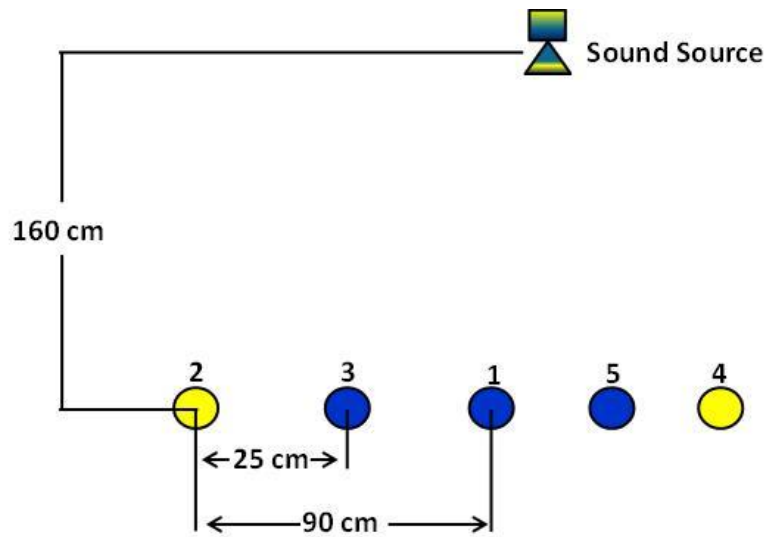


Figure 1 Measurement points of background noise

### 2.3 Measurement of Noise Level Using the Barrier

Measurements were made on two types of barriers, I and II. The effectiveness of noise barriers can be classified into three categories including ineffective, for IL value  $< 7$  dB, effective, for  $7 < IL < 10$  dB, and very effective, for IL value  $> 10$  dB. The source used is the type of white noise representing the traffic noise.

### 2.4 Data Analysis

The data obtained were analyzed using descriptive statistics on the value of Insertion Loss, efficiency, and effectiveness of the barrier in reducing noise. The results serve as a recommendation basis for SMAN 2 Cibinong to construct a noise barrier of either type I or II (type L) shapes.

## 3. RESULTS AND DISCUSSION

The results showed the noise around the location at SMAN 2 has a high level of  $\pm 60$  dB which exceeds the quality standards of 55 dB required by the Decree of Ministry of Environment (Kepmen LH) No. 48/1996 for school environments.

The background noise was measured as a comparison in an anechoic room (a free space echo) at a frequency of about 12.5 Hz – 20 kHz according to the normal human hearing limit in analyzing each  $1/3$  octave. Background noise without noise source is not audible because it

generally occurs at low frequencies with a noise level less than 6 dB. However, a value more than this is normally required for effective audibility by listeners in different positions (Kusuma, 2012).

The result obtained from the measurement of background noise using 8 kHz source has the highest average  $L_p$  value of 68.48 dB for all the three receiver heights of 30, 60, and 90 cm. It also showed the average sound pressure ( $L_p$ ) level using type I barrier to increase along with the height with 30 cm having the smallest average. This can be associated with the effect of the absorption of sound waves propagating in the air, rather than the surface of the barrier. Meanwhile, type II barrier has the average sound pressure ( $L_p$ ) of 200 cm length.

According to Bruel and Kjaer (1988), normal human ears are sensitive to changes in noise level  $\geq 3$  dB. Thus, this value was used as a basis to determine the effectiveness of noise control barriers. The Insertion Loss (IL) frequencies for both types I and II barriers were quite similar such that higher frequency leads to more effective noise reduction. The results of existing Insertion Loss value were analyzed to specify the degree of noise control effectiveness in compliance with the standards of the Federal Highway Administration (FHWA) and the New York State Department of Transportation (NYSDOT). It is considered as ineffective for an IL value of  $<7$  dB, effective for  $7 > IL < 10$  dB and very effective for  $IL > 10$  dB and seven frequencies were used, including the standard of low and high frequency.

Barrier type I was able to effectively reduce the noise level at high frequencies of 8 kHz, 1 kHz, 2 kHz, and 4 kHz, while low-frequency experiments yielded less favorable performance. Based on the aforementioned three categories of barrier effectiveness, the optimum lengths for type I were 200 cm and 180 cm, while the most effective heights were 30 cm and 60 cm.

**Table 1** Effective frequency for barrier type I

Frequency (Hz)	Point 1 (dB)	Point2 (dB)	Point 3 (dB)	Point 4 (dB)	Point 5 (dB)
125	13.08929	18.47953	14.18567	27.09164	24.00145
250	-18.77499	-13.11455	36.43916	-55.24839	5.88544
500	27.26252	39.18271	50.03741	53.56687	39.06337
1,000	77.25983	54.20067	71.58719	65.64921	65.90617
2,000	90.02307	91.59278	98.86096	82.61997	89.08041
4,000	59.70251	65.01983	45.66906	63.58691	56.79753
8,000	171.45104	144.37500	155.74454	110.50321	136.22560

As seen in Table 1 which was derived from the Insertion Loss analysis, the optimum noise control frequency for Barrier Type I was 8 kHz at Point 1. Such color scale depicts the distribution of noise reduction efficiency where the highest and lowest values are represented by green and red blocks, respectively.

**Table 2** Effective length for barrier type I

Barrier length	Point 1 (dB)	Point 2 (dB)	Point 3 (dB)	Point 4 (dB)	Point 5 (dB)
100 cm	54.08265	44.07841	50.19837	35.67317	43.11901
180 cm	56.70813	50.53001	53.95302	38.68671	45.87657
200 cm	60.66026	49.76657	51.59316	36.14333	47.23002

Table 2 indicates the optimum barrier length for noise reduction to be 200 cm at the receiving Point 1.

**Table 3** Effective receiver height for barrier type I

Receiver Height	Point 1 (dB)	Point 2 (dB)	Point 3 (dB)	Point 4 (dB)	Point 5 (dB)
30 cm	24.14940	19.22656	22.24664	18.01998	22.19667
60 cm	16.42998	15.49000	14.90995	11.89671	13.33336
90 cm	20.08088	15.05002	14.43657	6.22663	11.69998

As seen in Table 3, the optimum receiver height for noise reduction was 30 cm at Point 1. Based on the IL classification method, type I barrier is considered as an effective noise control structure at high frequencies of 8 kHz, 1 kHz, 2 kHz, and 4 kHz. Contrarily, it is less effective at low frequencies. A length of 200 cm and a receiver height of 30 cm were also obtained to be the most effective conditions for noise reduction using type I barrier. Meanwhile, Table 4 shows the optimum frequency for type II barrier also to be 8 kHz at Point 1.

**Table 4** Effective frequency for barrier type II

Frequency (Hz)	Point 1 (dB)	Point 2 (dB)	Point 3 (dB)	Point 4 (dB)	Point 5 (dB)
125	31.16688	35.63916	30.83113	41.17774	34.93282
250	18.45528	-16.72833	54.56260	-60.78583	14.04292
500	48.01143	58.08189	48.61174	35.20696	38.59605
1000	95.62094	73.28604	88.82716	77.47938	87.48180
2000	103.88367	99.98602	101.58729	96.02484	103.53649
4000	82.75300	80.90632	71.92142	67.25873	67.64238
8000	203.61426	176.32833	195.78872	141.98486	174.96196

Table 5 indicates the most effective length for Barrier Type II to be 200 cm at Point 1. Therefore, it can be concluded from the IL value distribution above that a longer barrier gives a greater level of noise reduction.

**Table 5** Effective receiver height for barrier type II

Receiver Height	Point 1 (dB)	Point2 (dB)	Point 3 (dB)	Point 4 (dB)	Point 5 (dB)
30 cm	26.38814	20.80331	25.66998	22.75988	27.92664
60 cm	24.71668	20.56350	22.26985	14.25002	21.25329
90 cm	23.53405	20.47328	20.07934	10.77912	17.44330

The table above shows the optimum receiver height for noise reduction using type II barrier to be 30 cm at Point 1. It showed 42% efficiency at a length of 200 cm and a height receiver of 30 cm which was 20 m long and 3 m high in actual sizes. This efficiency values are rather low (below 50%) due to the application of plywood material. According to the guidelines for the mitigation of the impact Due to the Traffic Noise (PD-T-16-2005), this material is only good at reducing the noise level at a dB Insertion Loss value of 18 – 19 using frequencies above 500 Hz.

The recommended barrier material is reinforced concrete which has a high resistance to fire and water and also unsusceptible to rust. Moreover, its maintenance cost is inexpensive, and it is more durable than other materials. Furthermore, the measurement was also influenced by temperature, humidity, and wind factors and the results showed type II barrier in the form of an arc (45° slope) with a length of 200 cm and a height receiver of 30 cm (20 m long and 3 m high in actual structures) made of 3 cm thick concrete slabs is recommended for SMAN 2 Cibinong. It

was chosen due to the greater amount of reflected sound waves on account of the 10 cm arch addition. This is in accordance with the FHWA and NYSDOT classification standards used in the United States.

#### **4. CONCLUSION**

It can be concluded that the most effective structure in reducing noise is the Barrier Type II with a length of 200 cm, the height of receiver of 30 cm and the efficiency value of 43%. Therefore, the recommended material is 20 m long reinforced concrete with a height receiver of 3 m. However, it was difficult to determine the optimum length barrier and height receiver at low frequencies IL measurement due to the presence of diffraction.

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